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Rapid distortion theory for Hall magnetohydrodynamic turbulence in astrophysical plasma

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Studied are statistical properties of astrophysical magnetohydrodynamic turbulent plasma flows using rapid distortion theory (RDT). The defining assumption of RDT is that the turbulence responds to the external distortion so fast, that inertial forces result in a negligible change in turbulent velocity field. We use RDT to study incompressible turbulent plasma flows distorted with large-scale linear velocity shear and external magnetic field for MHD and Hall MHD cases. It is considered that the response to an external effect takes place in a much smaller time interval compared to turbulence decay time. This assumption allows to linearize governing MHD equations and to derive dynamic equations for second moments of turbulence. It is shown that even with a strong nonlinearity statistical and topological properties of turbulence can be qualitatively studied using a linear theory. A closed system of linear equations for velocity and magnetic field fluctuations is derived. A closed system of linear equations for spectral tensors of velocity and magnetic field is derived. Development and transition to anisotropy of initially isotropic turbulence are studied. Dynamic equations for fluid, current and cross helicity are derived. Cases of rotating and non-rotating flows are discussed. Effects of plasma multicomponentness in dissipative scales are shown by considering in the Hall MHD approximation.